

Renewable Energy Research Using Floating Solar Photovoltaics (Fpv)

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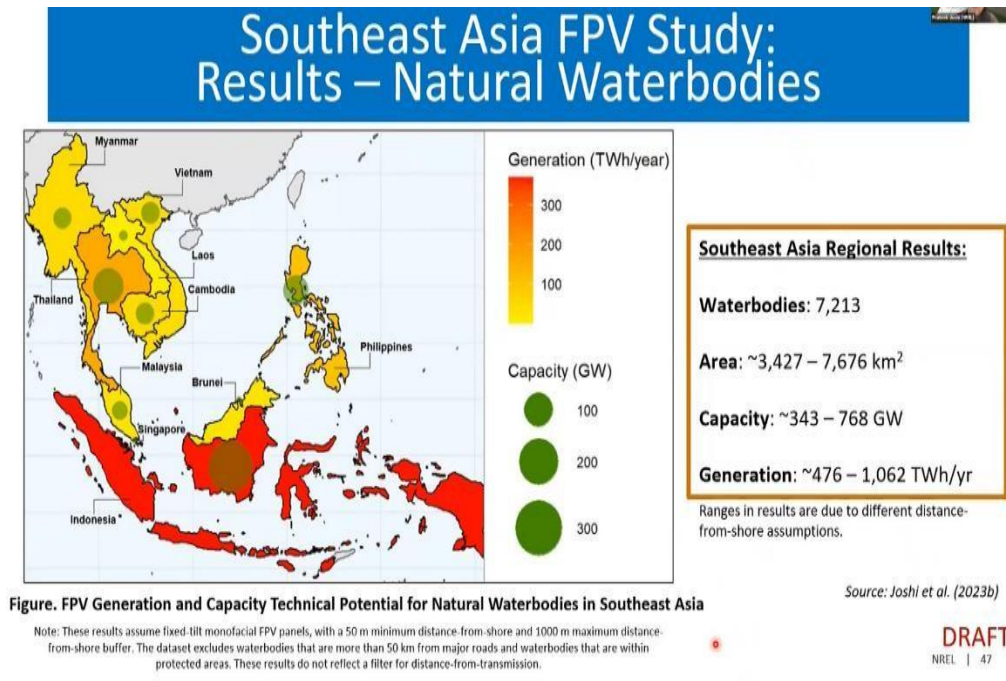
Abstract

Floating Solar Photovoltaics (FPV) is the latest innovation in renewable energy that offers great potential to meet global energy needs while reducing environmental impact. In the search for more sustainable and environmentally friendly alternatives to generate electricity, FPV has emerged as an attractive solution. This technology combines two key elements of solar photovoltaic panels and water, by installing solar panels on the surface of water, such as lakes, reservoirs, or even the sea. Floating Solar Photovoltaics not only represents an advancement in photovoltaic technology, but also creates new opportunities to address energy and environmental challenges. In this way, this technology represents an important meeting point between renewable energy and wise management of water resources. In this guide, we will explore the basic principles, benefits, challenges, and potential applications of FPV in the context of an increasingly sustainable global energy economy. Through Floating Solar Photovoltaics, we can maximize the use of abundant sunlight to generate electricity, while preserving water quality and the precious aquatic environment. This approach has the potential to transform the global energy landscape in a sustainable way and reduce our carbon footprint. Let us delve deeper into the concept of FPV and explore how this technology can help us achieve our renewable energy and environmental goals.

Keywords: floating solar photovoltaics, renewable energy, electrical energy

INTRODUCTION

This paper draws on the National Renewable Energy Laboratory (NREL) review of Floating Solar Photovoltaics (FPV), including its assessment of technical potential in Southeast Asia :



The assessment assumes monofacial FPV panels installed at a fixed tilt, with a minimum distance of 50 m from

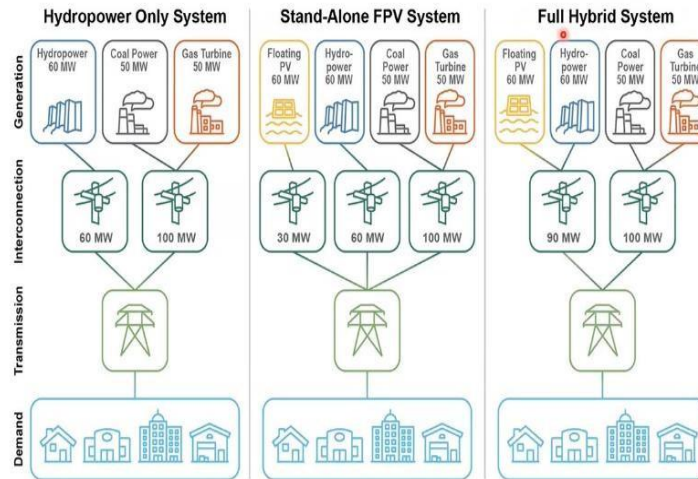


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the shoreline and a maximum distance of 1,000 m from shore-based support infrastructure. The dataset excludes water bodies located more than 50 km from major roads and water bodies situated within protected areas. The results do not account for filtering based on distance from transmission infrastructure.

FPV Hybrid Operational Modeling (1/2)

Research Question: What are the operational benefits of hybridizing FPV with hydropower?



Source: Gadzanku et al.
(2022)

Figure. Example System Configurations for the Hydro-Only (left), FPV Stand-Alone (middle), and Hybrid FPV-Hydropower (right) Systems

Figure 2. FPV operating model (Source: NREL)

Compared with a standalone FPV system, integrating FPV with hydropower can provide several benefits. It can support hydropower generation by conserving water and shifting hydropower production to other periods of the year (upper chart). The figure compares hydropower generation (upper panel) and FPV generation (lower panel) under different scenarios. Hybrid operation may also reduce PV curtailment when transmission constraints limit electricity delivery (lower chart) and reduce dependence on other generation sources, such as gas-fired power plants, by lowering PV curtailmen.

METHOD

The survey was conducted on 13 September 2023, focusing on Southeast Asia and Indonesia, using the Global Solar Atlas website.

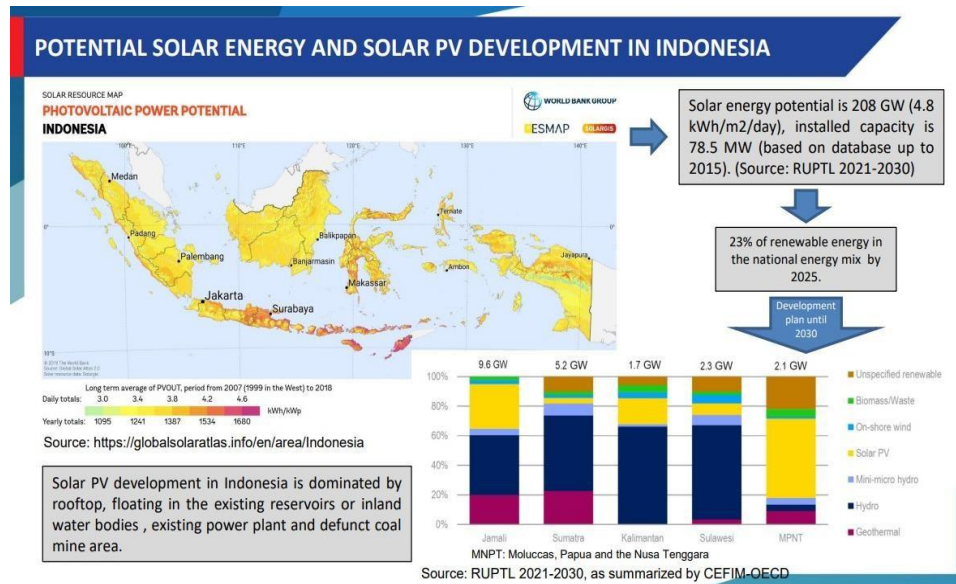


Figure 3. Solar-energy and FPV potential in Indonesia (Source: RUPTL)

Solar photovoltaic development in Indonesia has primarily focused on solar power plants installed on existing reservoirs or other inland water bodies, at existing power-generation sites, and at decommissioned coal-fired power plant sites. Indonesia's solar-energy potential is reported as 208 GW, with average solar irradiation of 4.8 kWh/m²/day, while installed capacity was 78.5 MW according to a database covering data through 2015. For offshore FPV, benchmark costs may differ because of factors such as transmission-cable costs and environmental loads. Nevertheless, the balance of system (BOS) remains the largest component of investment costs

RESULTS AND DISCUSSION

The advantages of FPV include more efficient use of land, potential energy-efficiency benefits, reduced water evaporation, flexibility in site selection, the possibility of greater deployment capacity, and support for sustainable development. Its disadvantages include technical challenges, potential environmental impacts, high initial installation costs, accessibility and maintenance requirements, interactions with the aquatic environment, and collision risks.

Installing Floating Solar Photovoltaics (Floating PV) in Indonesian marine waters or around ports requires careful planning and implementation. The following general considerations should be addressed:

1. Site assessment: Select a suitable location by considering water depth, currents, waves, weather conditions, and environmental and ecological factors. Preliminary studies are important for understanding local water conditions.
2. Permits and regulations: Comply with applicable Indonesian permits and regulations, including environmental and construction permits and approvals from relevant local and national authorities.
3. Floating PV design: Choose a Floating PV technology appropriate for the site's characteristics. Options include pontoon-based floating systems, mooring-line systems, and other floating structures. Select the design best suited to the local marine conditions.
4. Component selection: Select solar panels that can withstand marine conditions, together with suitable supports, inverters, and electrical equipment that meet applicable safety standards.
5. Environmental impact assessment: Conduct a comprehensive environmental impact assessment to understand potential effects on nearby marine ecosystems. Establish mitigation and, where appropriate, compensation measures to support ecosystem sustainability.
6. Installation of the floating structure: Installation involves deploying the floating structure and mounting the solar panels on it. The work should be performed by experienced personnel familiar with the marine environment.
7. Protection against severe weather: Design the FPV system to withstand severe weather, including storms, large waves, and tidal variations. Appropriate planning and weather-resistant materials are essential.



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8. Cable network: Connect the solar panels to the onshore electrical system using cables suitable for saltwater environments and ensure that the cable network is adequately protected.
9. Monitoring and maintenance: Install monitoring systems to track FPV performance continuously. Conduct routine maintenance to support reliable operation.
10. Security: Secure the FPV site against unauthorized access. Clearly mark the surrounding waters so that vessels and other maritime users are aware of the installation.
11. Training and safety: Ensure that personnel involved in FPV operations are trained and understand the relevant safety procedures.

Installing Floating PV in marine waters or around ports could support renewable-energy generation and improve port operational efficiency. However, such projects require careful planning and management, as well as a thorough understanding of the technical and environmental challenges involved. Experienced renewable-energy and environmental specialists should be consulted before a project begins.

Floating Solar Photovoltaics (Floating PV) has significant potential as an energy source for port operations. The potential benefits include:

1. Use of space: Ports often have limited land, which is needed for cargo storage and logistics facilities. FPV can use water surfaces near ports without occupying valuable land.
2. Energy diversification: FPV can diversify a port's energy supply. In addition to electricity from the conventional grid, FPV can provide an additional renewable source and reduce reliance on fossil fuels.
3. Reduced carbon emissions: As a renewable-energy technology, FPV can help ports reduce emissions associated with their operations and support sustainability objectives.
4. Lower energy costs: FPV may help reduce energy costs over the long term. Once installation costs have been incurred, sunlight provides the energy source for electricity generation.
5. Resilience: FPV systems can be designed to withstand weather variability, storms, and fluctuations in water levels. This may help maintain port operations during extreme weather, depending on system design and site conditions.
6. Water conservation: In some settings, FPV can reduce evaporation from port basins or other water bodies, potentially benefiting water management in relatively dry areas.
7. Modular installation: FPV can be installed in modules and adapted to port requirements. Capacity can therefore be expanded as needs change without major alterations to existing infrastructure.
8. Emergency power supply: During emergencies or grid outages, FPV may contribute to emergency power provision, subject to appropriate storage, grid-forming, and system design

The installation of Floating PV in Indonesian marine waters presents several challenges:

1. Waves and currents: Currents and waves can be strong in Indonesian waters, particularly near the coast. FPV systems must be designed to withstand hydrodynamic loads and strong waves, and must be installed securely.
2. Corrosion-resistant materials and waste management: The corrosive marine environment can damage FPV components. Routine maintenance and corrosion-resistant materials are important for reliability and service life.
3. Environmental effects: FPV may affect surrounding marine ecosystems. Careful environmental assessment and planning to minimize impacts are therefore essential, along with ongoing maintenance and ecosystem monitoring.
4. Permits and regulations: Obtaining permits and approvals for FPV in Indonesian marine waters may be complex, involving environmental and maritime permits and approvals from multiple authorities.
5. Site access: Accessing offshore FPV sites can be difficult, particularly when they are far from shore and require suitable vessels for maintenance and repairs.
6. Availability of trained workers: Some regions of Indonesia may have limited availability of personnel trained in FPV installation, maintenance, and monitoring.
7. Cost control: FPV may involve high upfront costs, especially when saltwater-resistant equipment and protection against severe weather are required. Project costs therefore need to be carefully managed.
8. Integration with the electrical grid: Integrating FPV-generated electricity into the existing onshore grid can present technical challenges and requires adequate cable infrastructure.
9. Safety and security: FPV systems must be protected against theft and vandalism. Appropriate warning signs



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and security measures are also needed to alert vessels and other maritime users to the installation.

10. Climate resilience: FPV systems should be designed to withstand increasingly extreme climatic conditions, including sea-level rise and damage caused by severe weather.

CONCLUSION

Installing Floating PV in Indonesian marine waters could provide a valuable option for renewable-energy generation. However, implementation faces complex challenges, particularly those associated with the region's distinctive climatic and marine environments. FPV projects should therefore be developed through careful planning and a thorough understanding of the local factors that may influence their success..

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